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The Evolution of ADAS: Testing Systems That Include Cameras, Radar, and Sensor Fusion

Smarter Test for Smart Vehicles

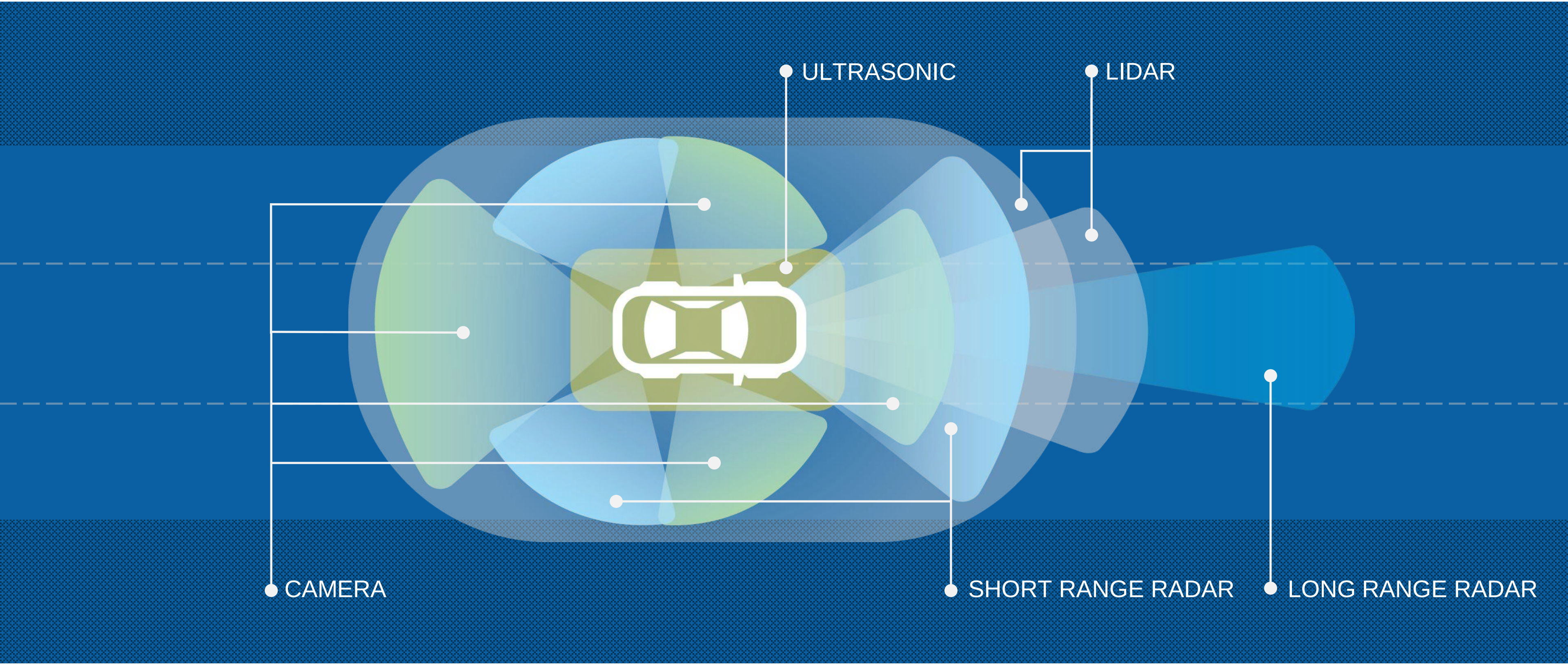
Jamie Smith

Director of Automotive Strategy

Pete Pragastis

General Manager, NI Microwave Components

ADAS Demands New Test Approaches



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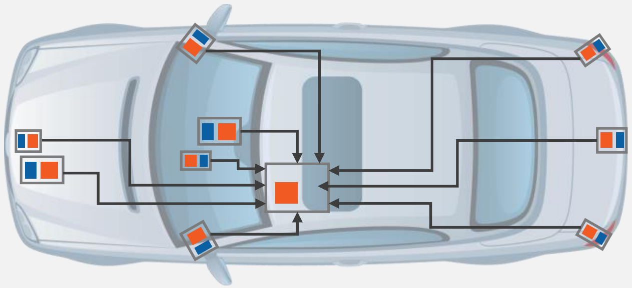
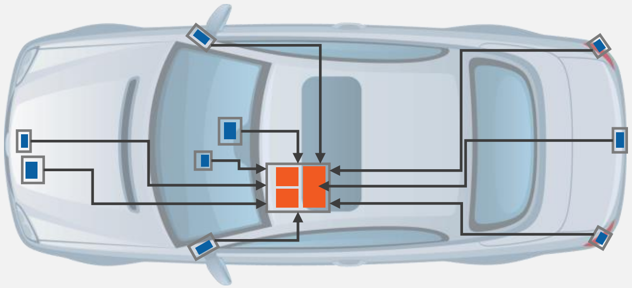
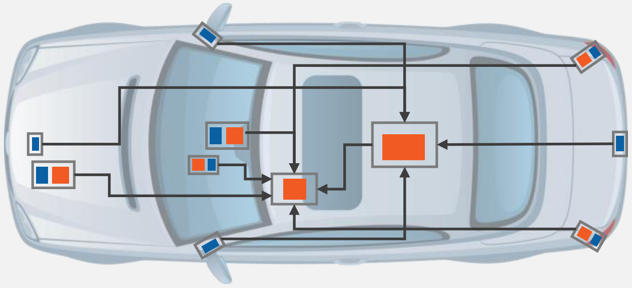
ADAS Architectures Continue to Evolve



SMART SENSORS/DECENTRALIZED PROCESSING



RAW SENSOR DATA/CENTRALIZED PROCESSING

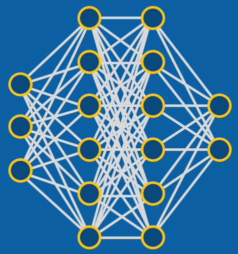


HYBRID SENSOR/PROCESSING

Sensor

Electronic Control Module (ECM)

Source: electronics-eetimes

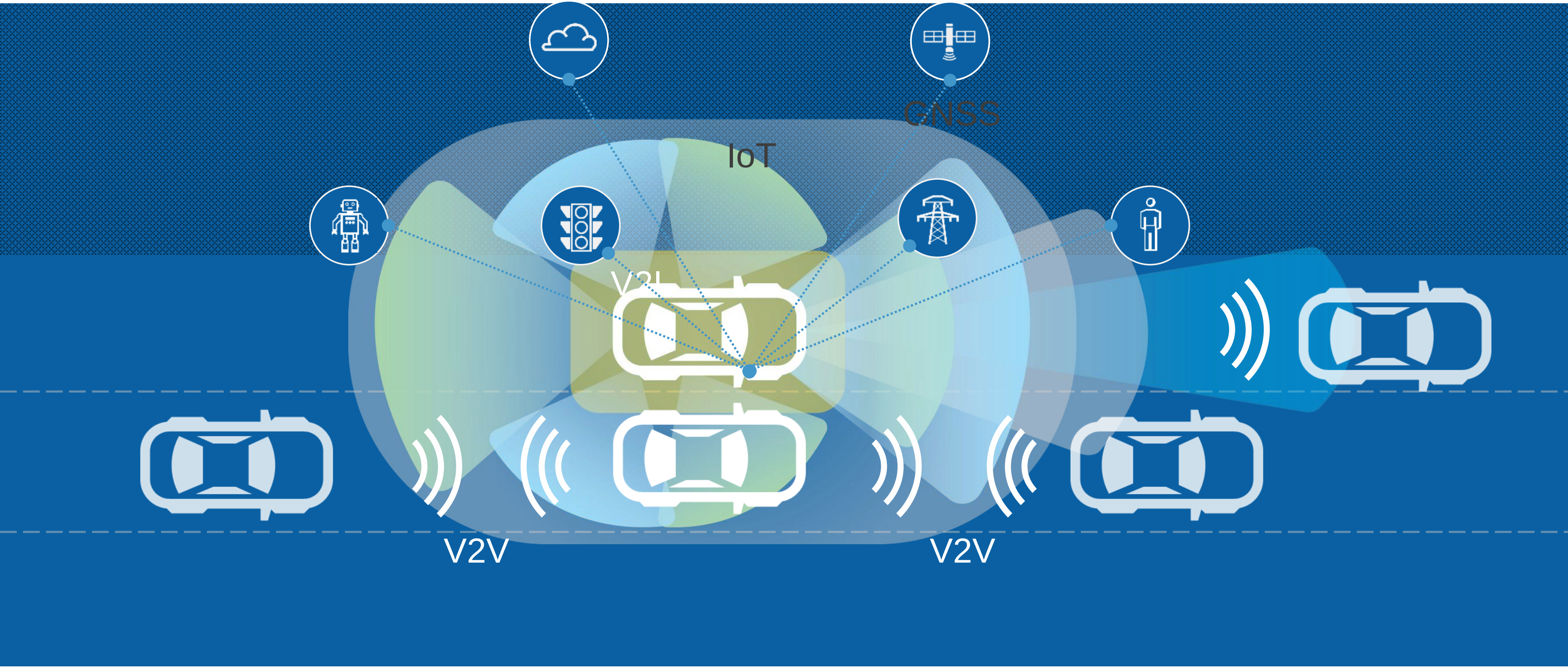


DEEP NEURAL NETWORK

Deep Learning for Self-Driving Cars

- Environmental perception is key to autonomous driving, e.g., lane position
- Traditional feature recognition and image processing techniques don’t scale to needed complexity
- Deep neural networks learn efficient feature representation
- Inductive learning leads to evolving software operation that is challenging to test

The Connected Car



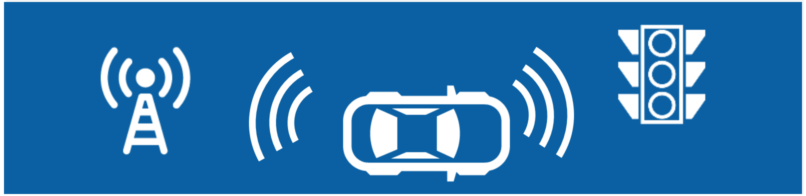
V2V and V2I Communications With 802.11p and LTE

IEEE 802.11p (DSRC)

- Referred to as Direct Short-Range Communication (DSRC)
- Uses unlicensed spectrum in 5.9 GHz band
- Based on half-clocked IEEE 802.11a/g with 10 MHz channel bandwidth
- Effective Tx-Rx velocity differences of up to 200 km/hr
- Supports only V2V communication

LTE V2X (Cellular V2X)

- Part of 3GPP Release 14; targeted for 2017
- Uses existing licensed LTE spectrum and infrastructure
- Bandwidth configurations up to 10 MHz
- GNSS-based symbol synchronization
- Supports both V2V (PC5) and V2I (Uu) modes



Inside the Self-Driving Tesla Fatal Accident

By ANJALI SINGHVI and KARL RUSSELL UPDATED July 12, 2016

Tesla car mangled in fatal crash was on Autopilot and speeding, NTSB says

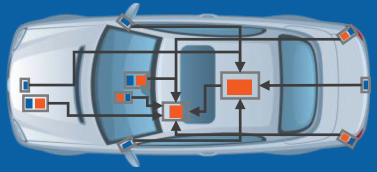
Tesla driver dies in first fatal crash while using autopilot mode

The autopilot sensors on the Model S failed to distinguish a white tractor-trailer crossing the highway against a bright sky

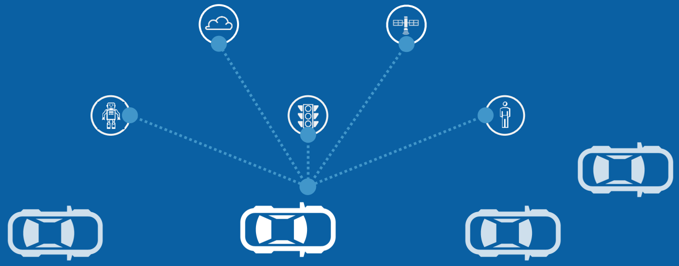
Who Has Ownership?

Testing ADAS and the Autonomous Vehicle

SENSOR



CAR



CONNECTED CAR WORLD

Characterization

Validation

Software (HIL)

Track and Road

Production

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Challenges of ADAS Testing

Regulatory
Uncertainty

Volume
of Tests

Testing Systems Instead
of Discrete Components

Integrating New Technology
Into Existing Systems

ONE-PLATFORM APPROACH

NI ECOSYSTEM

NI SERVICES AND SUPPORT

Community
300,000+ Online Members
450+ User Groups
9,000+ Code Examples

Academia
8,000+ Classrooms Worldwide

Partners
1,000+ Alliance Partners
Industry-Leading Technology Partners

Support
700+ Field Engineers
700+ Support Engineers
50+ Worldwide Offices

Add-Ons
400+ Software Add-Ons
5M+ Tools Network Downloads

Open Connectivity
10,000+ Instrument and Device Drivers
1,000+ Sensor and Motor Drivers

NI ECOSYSTEM

Radar

Autonomous Driving Requires New Sensing Technology

24 GHz Radar
(shared spectrum)

200 MHz Bandwidth
1.5 m Resolution

77 GHz Radar
(dedicated spectrum)

600 MHz Bandwidth
0.5 m Resolution

79 GHz Radar
(dedicated spectrum)

4 GHz Bandwidth
0.1 m Resolution

1959
General Motors integrated a modified airplane radar to indicate braking distance on Cadillac Cyclone

1971
First blind-spot detection (BSD) radar at 16 GHz presented at Bendix Labs in Southfield, Michigan

1975
First road testing vehicles Using 35 GHz radar for automatic cruise control and anti-collision

1993
Radar-based 24 GHz collision warning system reduces accidents by 21% for Greyhound busses

1998
Mercedes-Benz DISTRONIC System uses 77 GHz band

2004
European Commission harmonized use of 79 GHz band for short-range radar

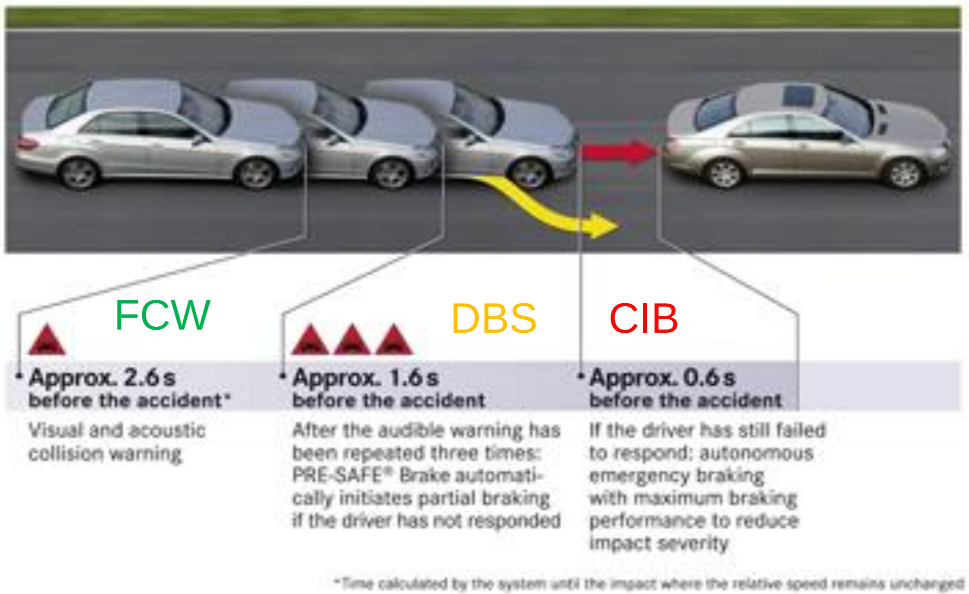
2006
Mercedes-Benz DISTRONIC PLUS uses 24 GHz radar for short range 77 GHz band for long range

2006
Field trials of 60 GHz automotive radar systems on Jo-Shin-Etsu Highway in Japan

2014
Delphi ships 1 Millionth 77 GHz electronically scanning radar (ESR)

2016
National Highway Traffic Safety Administration announces that all automakers will supply collision avoidance by 2022

Minimum Emulated Distance & Update Rate - Importance



Definitions *(from NHTSA)*

AEB: Automatic Emergency Breaking

TTC: Time To Collision

FCW: Forward Collision Warning

DBS: Dynamic Brake Support

CIB: Crash Imminent Break

Test Speed	Travel Dist.	TTC for FCW	TTC for DBS	TTC for CIB	Dist. to T_0
25mph/40kmh	11m/Sec.	3.0 Sec.	2.1 Sec.	1.1 Sec.	10-12m
45mph/72kmh	20m/Sec.	2.6 Sec.	1.6 Sec.	0.6 Sec.	2-4m
typ. Euro NCAP AEB Automatic-Emenrgency-Breaking Scenario					

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NI Vehicle Radar Test System (VRTS)

Flexible solution for 76-81GHz automotive radar measurement and object emulation down to 4m

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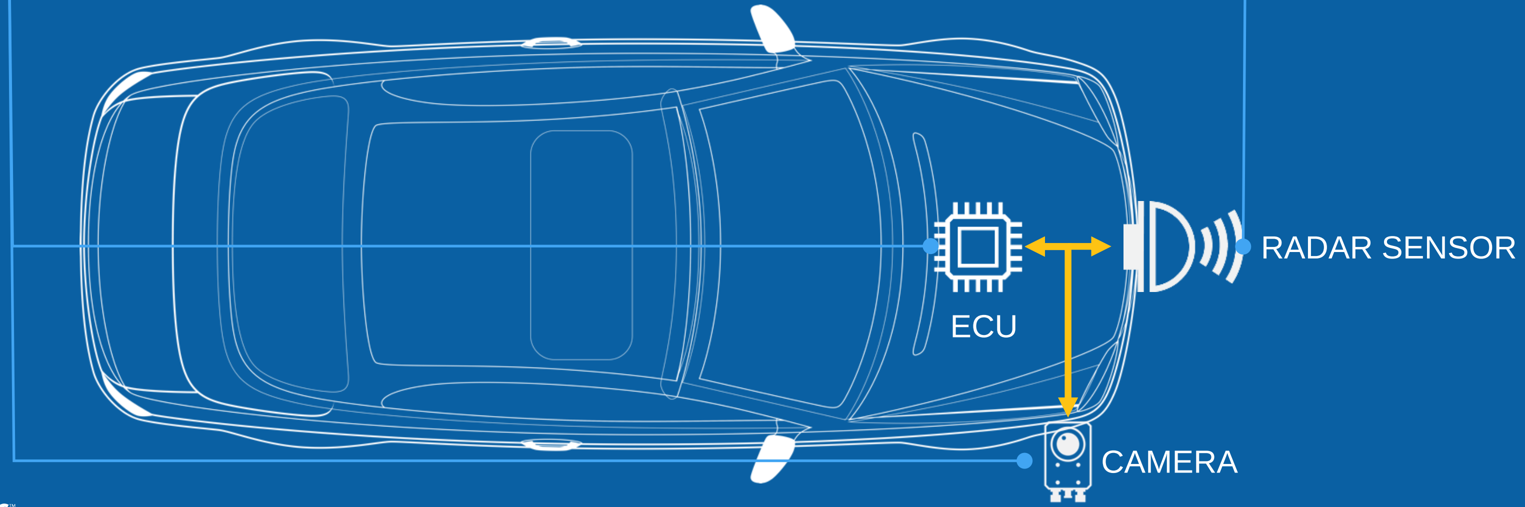
NI Offers Single Platform for Hardware and Software Test

Hardware-in-the Loop Test (HIL)

- Mathematical Modeling
- Scenario Generation
- Emulate multiple vehicle sensors

Characterization & Test

- Measurement IP
- I/O from DC to mmWave
- Instrument-Grade



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NI Vehicle Radar Test System (VRTS)

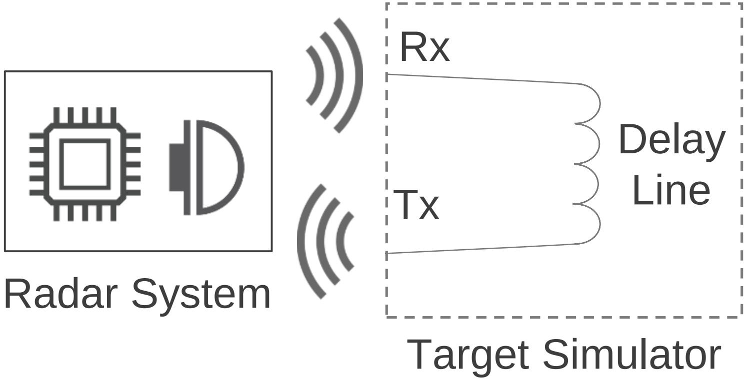
FEATURES AT A GLANCE

- Single system performs both object simulation and radar measurements
- Tight synchronization with modular PXI hardware for hardware-in-the-loop (HIL) and ADAS test applications

KEY SPECIFICATIONS

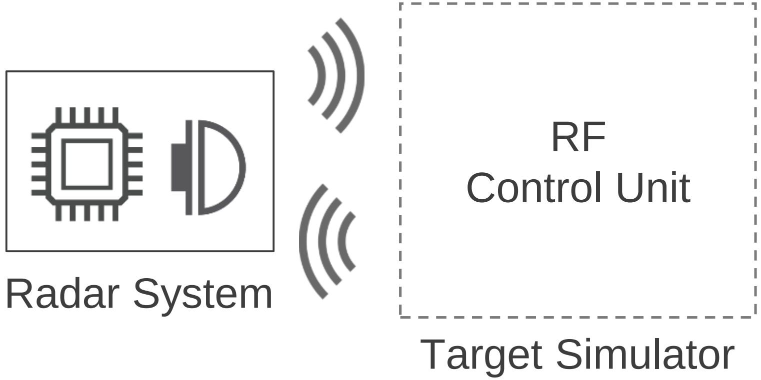
- Frequency Range: 76 – 81 GHz @ 1GHz Bandwidth
- Number of Obstacles: 1-4 per PXI chassis
- Obstacle range: 4 to 300+ m
- Distance Resolution: ~10 cm
- Distance Accuracy: ± 15 cm
- Velocity: 0 to 500 km/hr (75 kHz Doppler)
- Update Rate: <10mSec.

PASSIVE TARGET SIMULATOR



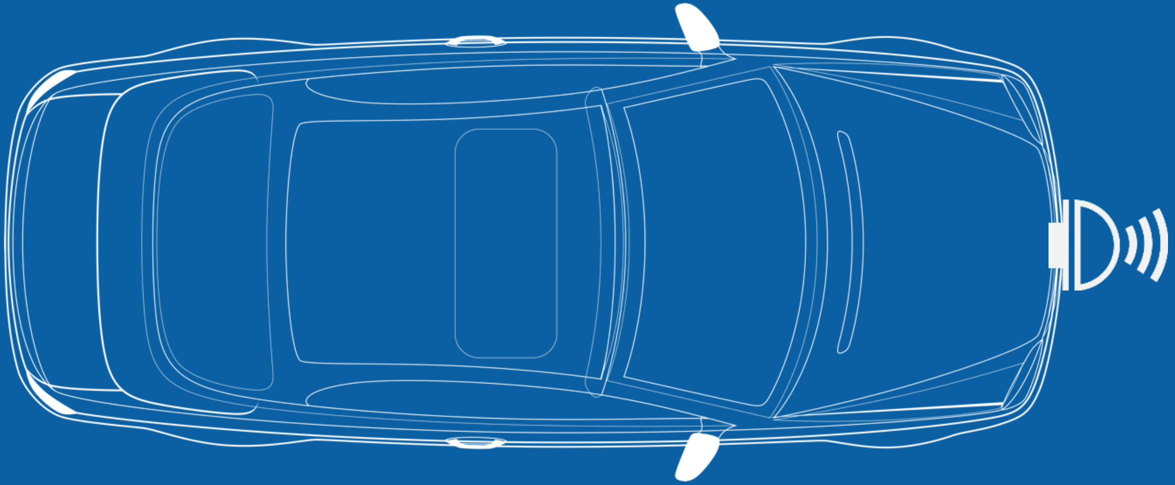
- Simple set-up
- Best for fixed targets
- Simulates fixed range of distances
- Limited doppler and radar cross section

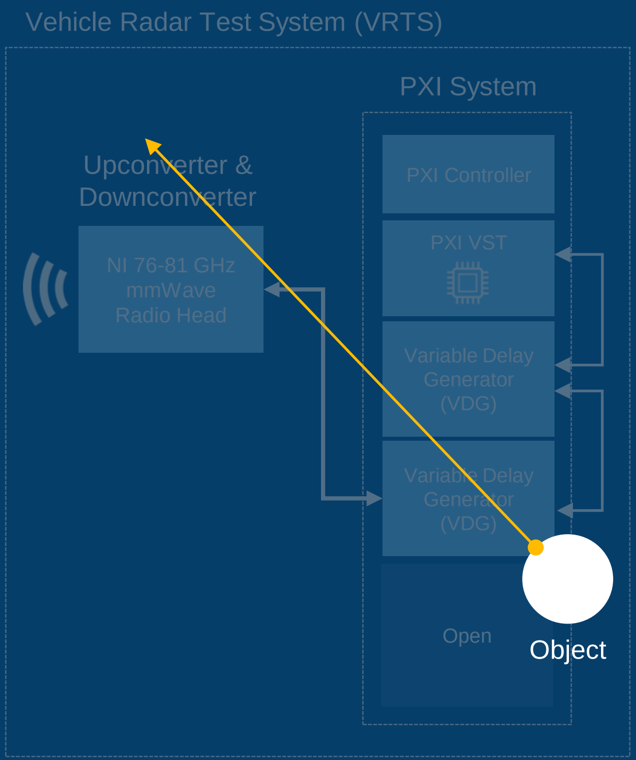
ACTIVE TARGET SIMULATOR



- Simulate multiple independent targets
- Advanced Doppler simulation
- Variable target control
- Complex scenarios possible
- Minimum distance dependent on RF control unit delay

Emulating Radar Targets





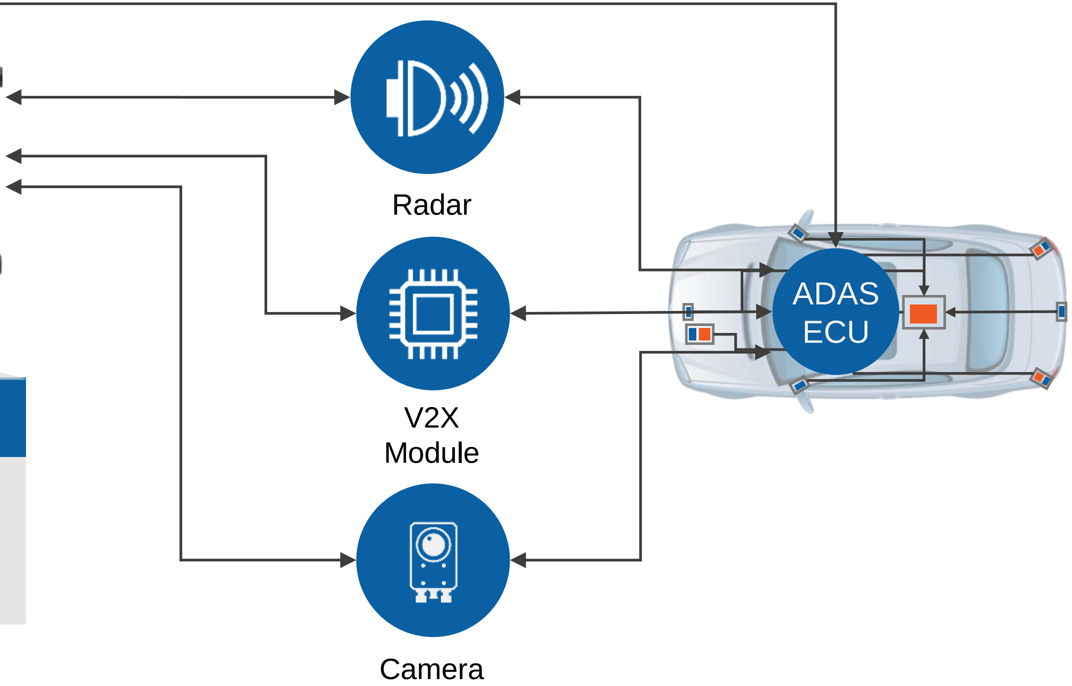
Object emulation re-creates the electromagnetic signature of a radar environment.

A Single Automotive Test Platform

CAN, FlexRay, and Ethernet

Flexible Test Platform

- Hardware-in-the-Loop
- Validation Testing
- Production Testing



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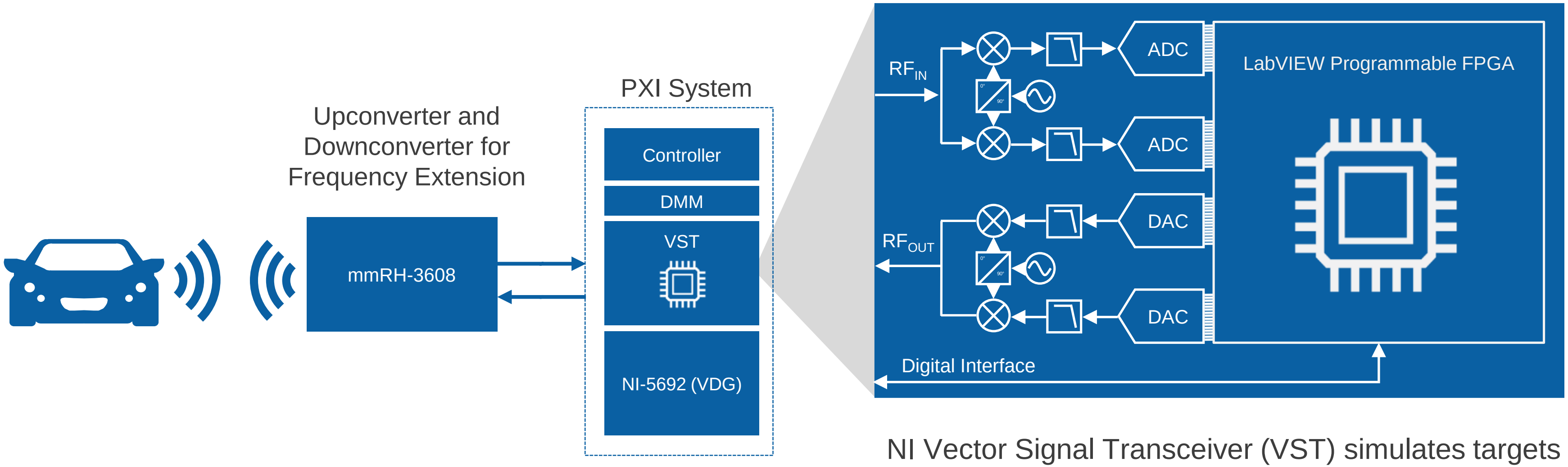
Block Diagram of Active Radar Target Simulator



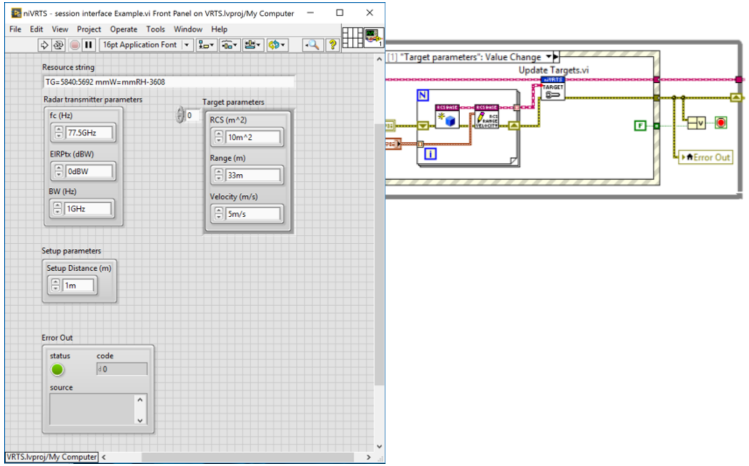
NI Vector Signal Transceiver (VST) simulates targets using LabVIEW FPGA-based signal processing

- Doppler shift via Tx-to-Rx frequency offset
- Distance to target via delay
- Multiple targets

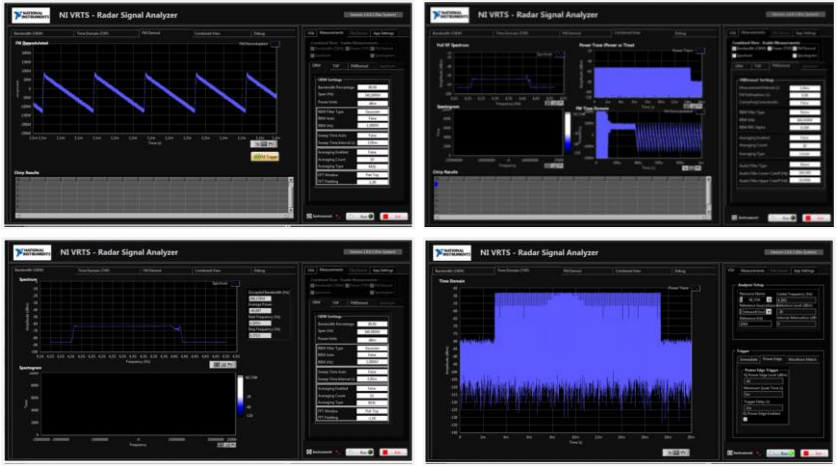
Inside the VRTS Software

NI Partners build on VRTS LabVIEW reference application

- Measurement examples for radar hardware characterization
- Object simulation examples for embedded software and system test



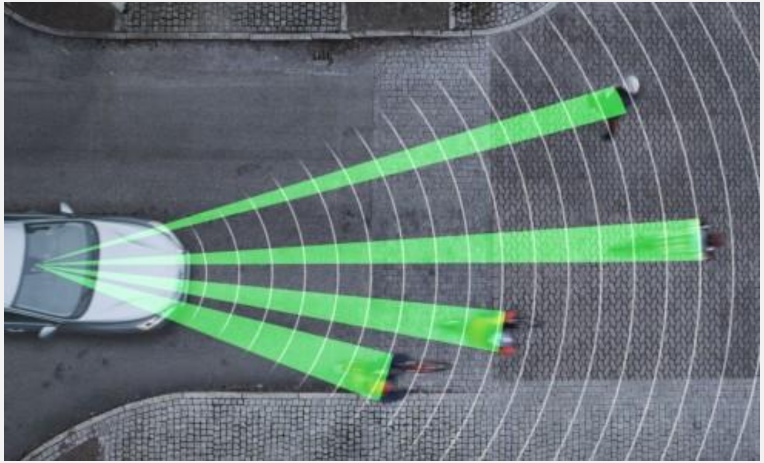
Radar Object Emulation



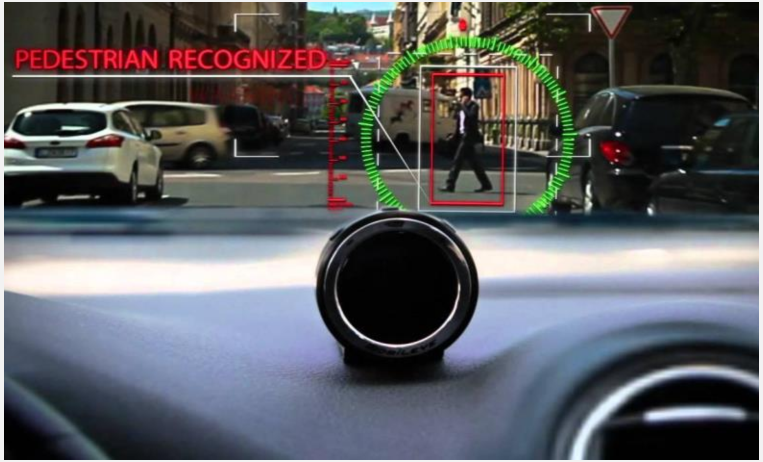
Radar Measurements

Sensor Fusion

Cameras and Radar Working Together

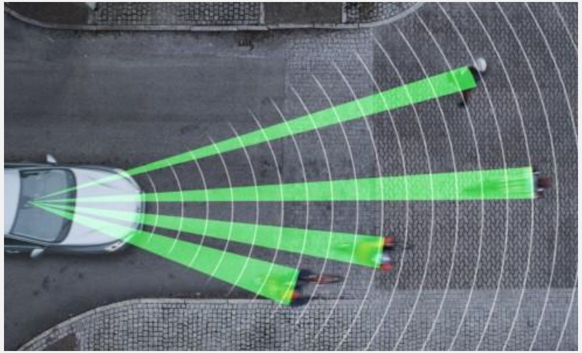


Object Detection Using Radar



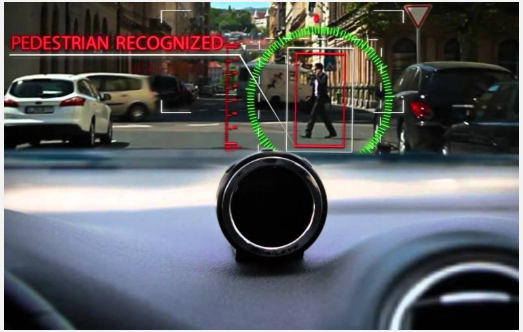
Object Classification Using Cameras

Cameras and Radar Working Together



Object Detection Using Radar

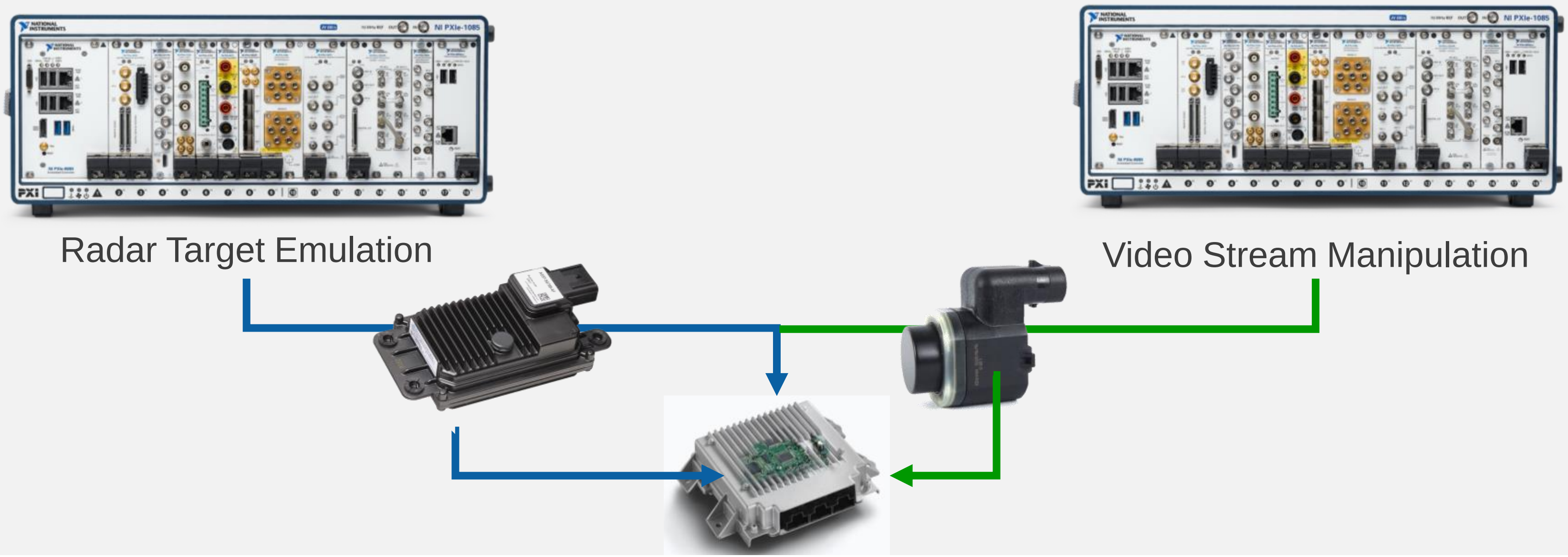
Synchronization



Object Classification Using Cameras

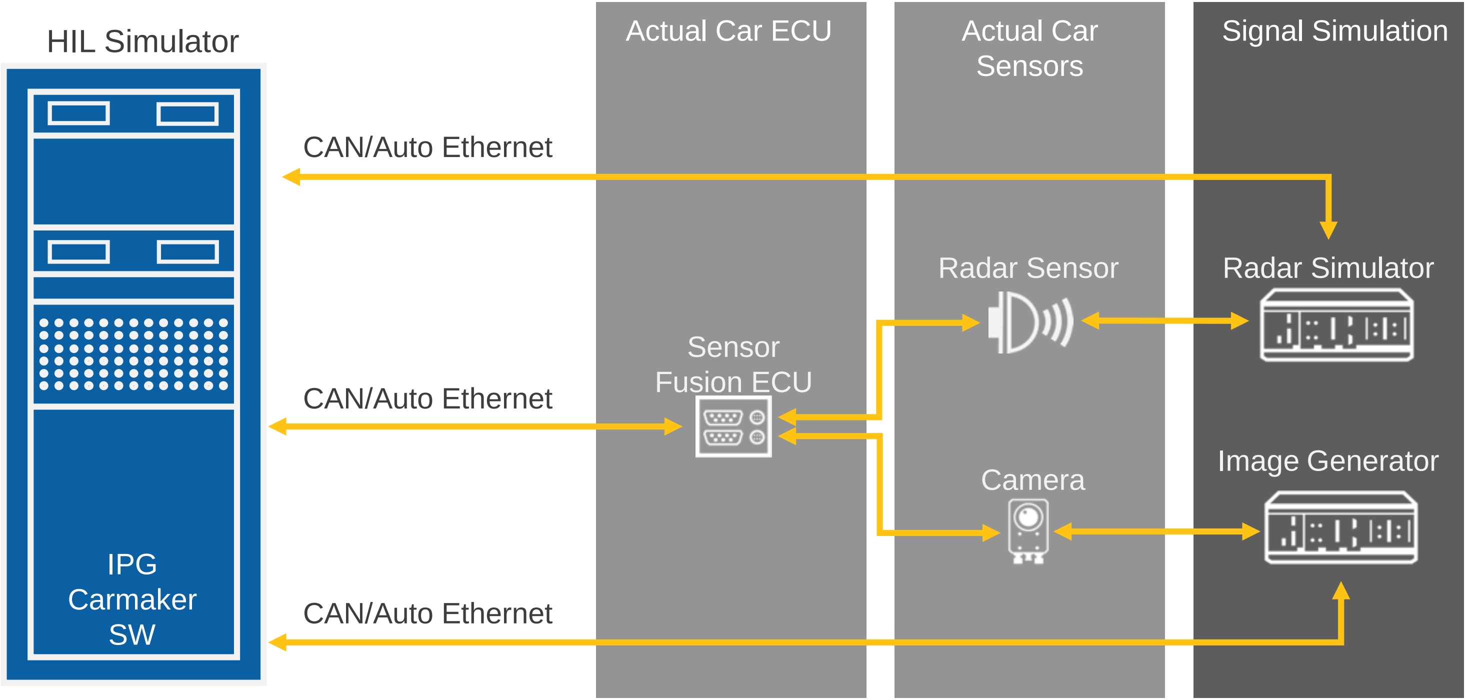
ADAS ECU for Safety Operations

Testing Sensor Fusion Embedded Software



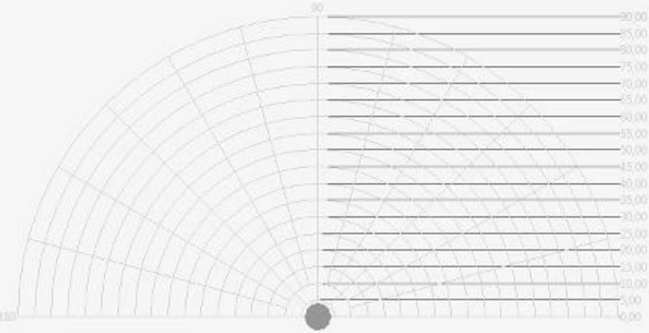
ADAS ECU for Safety Operations

HIL Simulation with Sensor Fusion is Essential for ADAS Design and Test



ADAS - Sensor Fusion

RADAR TEST



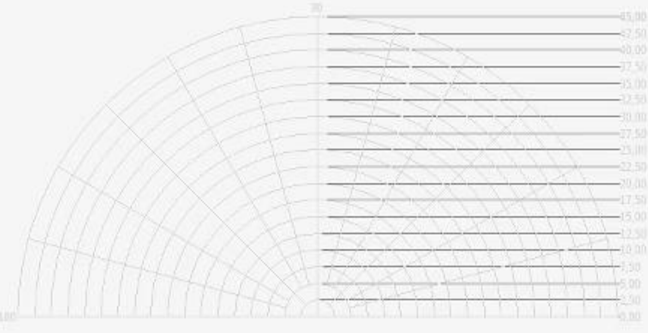
RADAR Information

Channel	Value
ObjAngle	0,000000
ObjRCS	0,000000
ObjRange	0,000000
ObjStatus	0,000000
ObjVelocity	0,000000

LiDAR TEST

LiDAR Beams Information

Channel	Value
Beam 1	0,000000
Beam 2	0,000000
Beam 3	0,000000
Beam 4	0,000000
Beam 5	0,000000
Beam 6	0,000000
Beam 7	0,000000
Beam 8	0,000000
Beam 9	0,000000
Beam 10	0,000000
Beam 11	0,000000
Beam 12	0,000000
Beam 13	0,000000
Beam 14	0,000000
Beam 15	0,000000
Beam 16	0,000000



CAMERA TEST

CarMaker Scenario

Vendor Strategies for Test and Measurement

CLOSED

- “Vendor knows best”
- Fixed-functionality
- Closed ecosystem
- Customer pays

PLATFORM

- “Customer knows best”
- Customizable solution
- Open, vibrant ecosystem
- Customer designs

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